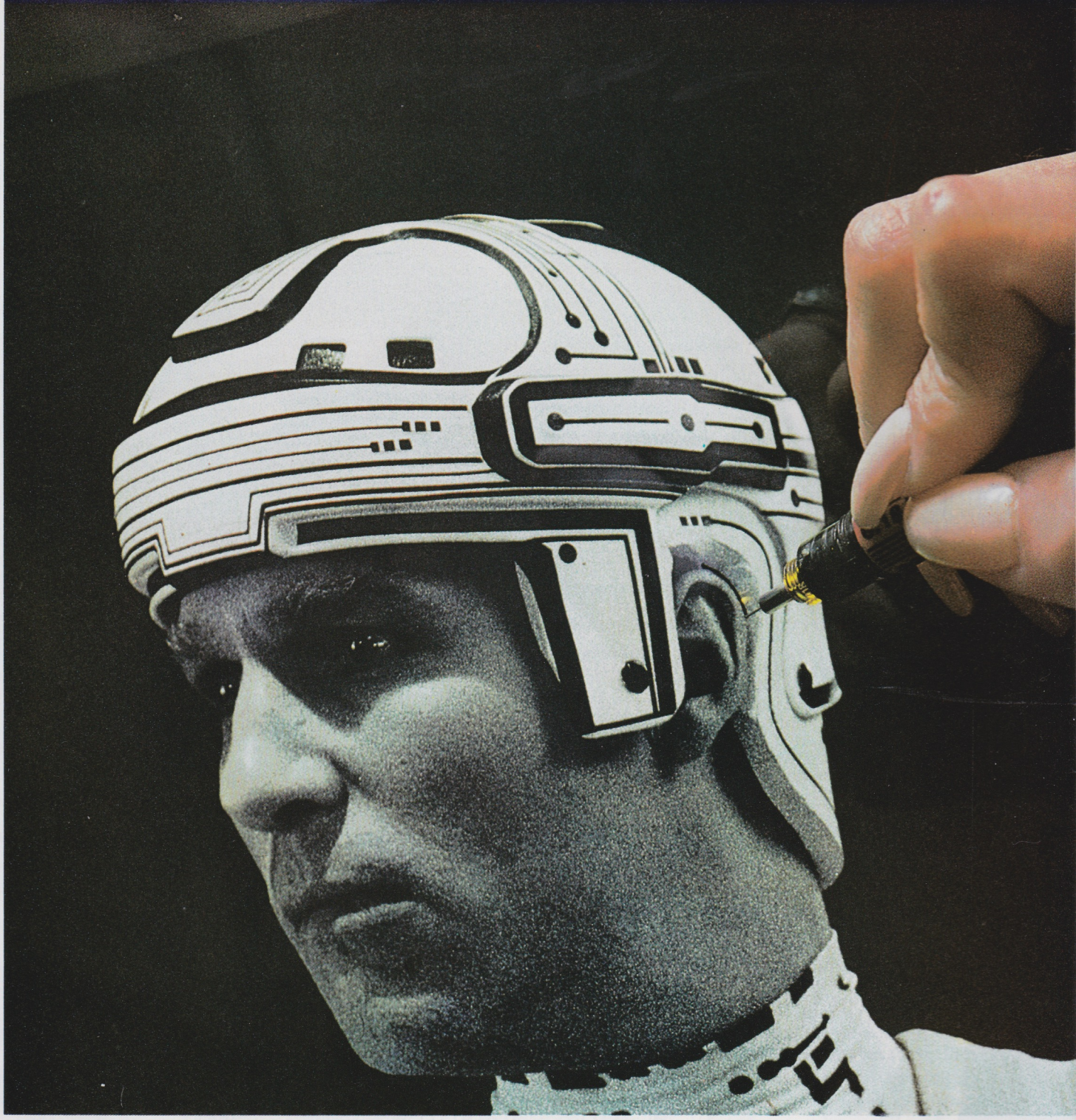


At Disney Studios, an inker does final touchup on the "circuitry" of Jeff Bridges' helmet.

By Michael Schrage

Computer animation comes of age in a studio on 'Dopey Drive'

In TRON, *a wild new Walt Disney movie, the electronic graphics of video games and television ads invade the silver screen*

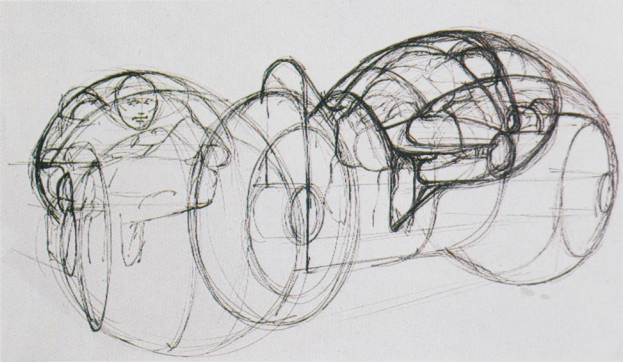
Walt Disney Productions

Computer warrior catches his boomeranglike "identity disk," a weapon that "de-rezzes" its target on impact.

The Disney tradition of animation did not start with a mouse; it began with a little girl named Virginia Davis. In the early 1920s, she starred in Disney's first series, *Alice in Cartoonland,* as an enterprising tot who always finds herself in animated adventures. The series was one of the first that believably blended a live-action character into an animated world and audiences loved it. Its success established Walt Disney in Hollywood where he released Oswald the Rabbit, Mickey Mouse and a whole menagerie of cartoon characters into the mainstream of popular culture. At its peak in the 1930s, Disney animation was simultaneously state-of-the-art and box-office smash.

Half a century later, an $18-million science-fiction epic called *TRON,* being released this month, is reviving some of the magic that has worn off the Disney image over the years. *TRON* (named for one of the electronic warriors in the film) represents the new generation of movie animation. Like *Alice in Cartoon-*

Photographs by Peter Angelo Simon



First step in creation of futuristic Light Cycle for the movie *TRON* is Syd Mead's rough sketch.

At MAGI, cycle is created out of 57 geometric forms (some outlined in red), combined in computer.

land, it features live-action characters in an animated setting; but in this era of the silicon chip, Disney animation is not only being crafted by hand, it is also being generated by computer.

The result is a set of images as visually exciting as anything ever done for the screen. Light and color have a different texture; objects that have never been move in ways that cannot seem to be. It is a quality and style of animation that looks nothing like classic Disney—but, in its own way, might turn out to be neo-classic Disney.

TRON is the story of a group of programmers who are electronically "sucked" into the circuitry of a powerful communications conglomerate's computer. The computer—ruled by its Master Control Program, the MCP (pp. 90-91)—seeks to overthrow the "users"—the people who run the computer. As digitized warriors, the programmers have to battle their way through a video-game grid and computer terrain to face the MCP. Among the film's stars are a young programming genius played by Jeff Bridges, a computer-world villain played by David Warner, and the MCP played by several million digital polygons.

Despite their reputation as tools for business and science, computers are basically symbol manipulators. In the discipline of computer graphics, the computer is not juggling numbers or rearranging words, it is keeping track of points, line segments and surfaces. *TRON* director Steven Lisberger looked at the most advanced techniques in computer graphics and decided they could be brought to the big screen.

The author writes a video column for Rolling Stone *magazine and contributes to other publications on a variety of new media topics.*

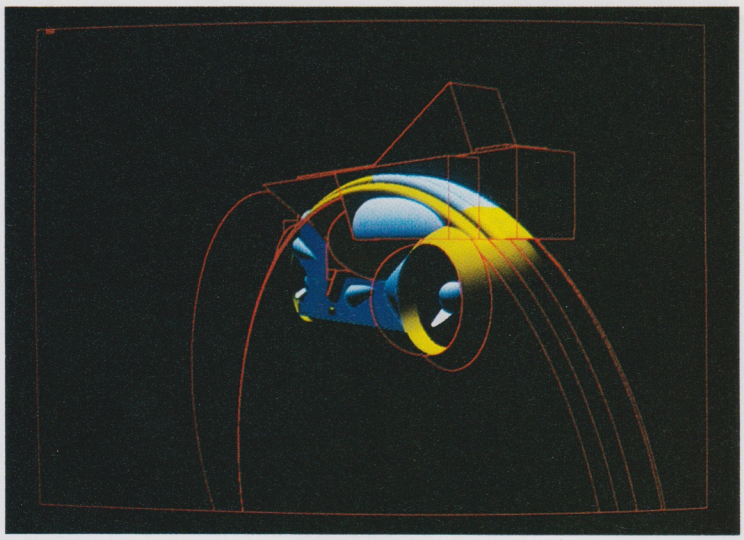
With his dark beard and black leather jacket, the 31-year-old Lisberger looks like a Hell's Angel of computers. He is bright and has a quirky sense of humor; to keep his actors "psyched up" for *TRON,* he installed a bank of four video arcade games for play between takes—or to break the tension when a scene was not going well. In his own trailer at Disney Studios in Burbank, Lisberger kept a Battlezone game to divert him in his off moments.

A graduate of the Hill School in Pennsylvania, Lisberger earned a master's degree in film from the Boston Museum of Fine Arts. While at graduate school, Lisberger and a few friends formed Lisberger Studios, specializing in animation. *Cosmic Cartoon,* one of the studio's shorts, won a Student Academy Award nomination in 1973.

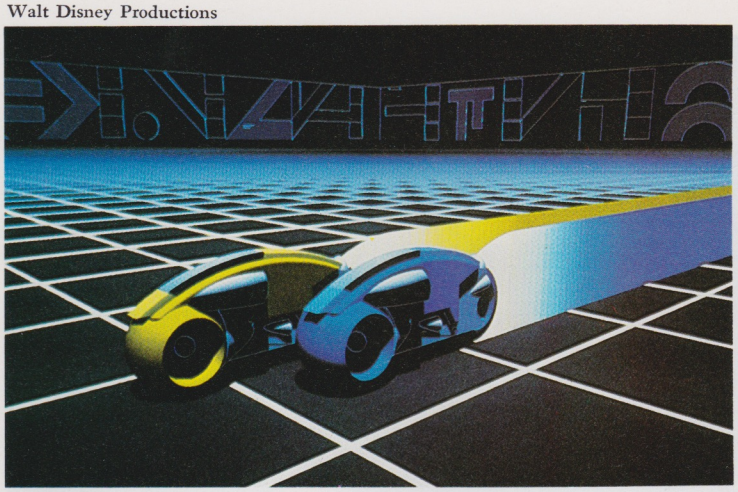
The 1976 Olympics inspired Lisberger to conceive *Animalympics*—an animated parody of the summer games featuring different animals competing in the events. The idea ballooned from a $10,000 American Film Institute grant to a million-dollar made-for-television movie that was dropped from the NBC schedule when the Olympic boycott was announced. It eventually appeared on cable TV.

Around that time, Lisberger became interested in the embryonic video-games fad. "I came across video games in the standard way," Lisberger recalls. "I spent Christmas with my wife's family and they'd just bought the new video games so we sat around and played them.

"What intrigued me was that, initially, I had a great fear of technology. My background is in the artistic side and that's just the opposite of, 'Hey, I wanna get a computer and really become Mr. High Tech.' But once I started getting involved with the games I found



Walt Disney Productions



In movie, Light Cycles racing across a video-game grid can execute dazzling, unlimited maneuvers.

that they automatically suggested human aspects. It was really neat to see all this computer stuff becoming subservient and silly enough to play video games. I realized that video games were a bridge to all of computer technology. That, I thought, was wonderful."

Soon Lisberger came to regard a video game as more than blips on a screen. "I looked upon it more as a medium than as a game. It was the first time that animation had gotten involved with technology to break the shackles that had been holding it for 20 or 30 years. It became unpredictable; it was capable of doing things on the spur of the moment that were in no way what you expected it to do. And, at that point, the thing seemed to be living."

Lisberger then began to investigate the computer-graphics field to see if computers could generate the kind of animation a movie like *TRON* would demand. Computer graphics had long been the technological preserve of the military and industrial establishments for engineering and design purposes. The potential for graphics as special effects in movies had, technically, existed for a long while—but no one had taken the gamble to see if they could be tamed for the big screen. In June 1980, Lisberger and producer Donald Kushner approached Tom Wilhite, Disney's vice president for motion-picture production, with the *TRON* idea. They showed him a two-minute reel of some state-of-the-art computer graphics animation. On the strength of that, Wilhite authorized a $50,000 investment to get a better picture of what computers and artists could bring to the movies.

The result, along with the hope that *TRON* would establish an innovative direction for Disney Studios, convinced Wilhite to give the go-ahead—originally at a budget of $11.5 million. It would be Lisberger's first feature. "I was a Walt Disney freak," he says puckishly. "No doubt about it. I'm still a Walt Disney freak," he laughs. "I'm a freak at Walt Disney."

With Disney backing, Lisberger began assembling a creative group to develop a series of images that computers could stylize and animate to bring a believable fantasy world to the large screen. French graphic artist Moebius—one of the founders of the surrealistic *Heavy Metal* magazine—was called in to visualize characters that might inhabit a computer world of light and energy; futurist Syd Mead designed some of the transportation vehicles (above) that would speed down *TRON* highways and byways.

Four companies—Information International, Inc. (also known as Triple-I), MAGI (for Mathematical Applications Group, Inc.), Robert Abel and Associates (best known for their vibrant and surrealistic television commercials for Levi's jeans), and Digital Effects—were assigned different parts of the *TRON* world to bring to life. One of the areas that both Digital Effects and Robert Abel worked on was the opening-title sequence. The bulk of the work on the movie was done by MAGI and Triple-I.

Richard Taylor—tall, bearded and, like Lisberger, encased in a leather jacket—supervised the corporate quartet and set the esthetic tone. "We want to create images that remind you of something you've never seen before," he says with droll sincerity.

Taylor's task was to produce computer imagery that would behave on the screen. The trade-offs and the opportunities to do something truly eye-catching and elegant had to be carefully assessed. Like traditional hand animation, computer animation begins with an empty frame to fill. With the computer as an animator's medium, filling it becomes a job that, quite liter-

Triple-I animator Larry Malone scans polygonal MCP face, "skeleton" for finished version (right).

In film, Master Control Program (MCP) engineers attempted overthrow of its creators—the programmers.

ally, now requires an extra dimension of complexity.

"Conceptually," says Taylor, "you have to start to think in terms of a three-dimensional reality rather than a two-dimensional plane. In computer simulation—and I use the word *simulation* intentionally, not animation—the computer is always thinking of whatever you're dealing with in a three-dimensional Cartesian-coordinate reality. It's just that the result of all that calculation ends up being mapped upon a two-dimensional plane that happens to be film. It depends on where you put the eye in that three-dimensional reality—there is no camera."

With the computer as the camera, the questions shift from the limitations of the animator and his tools to the animator and his creativity. "The simulated objects themselves," says Taylor, "have no physical limitations. They can pass through each other; metamorphose; they can be infinitely big or small. There is no limit to your point of view. You can be inside an object, pass through its walls and be a million miles away from it two seconds later. There is no limit to your *angle* of view; you can look at something with 180-degree angle of view or one-degree."

Unlike traditional animation, computer animation plots out each point and line with mathematical rigidity and precision. The quality of light, of reflection, of angle, of color are all part of multiple equations interacting to produce an image on the screen.

"It's innately perfect," says Taylor. "If there is one problem with it, it is too perfect." One of the main problems involved in good computer design these days is to make it more human. Taylor muses that he might have to develop a mathematical formula for imperfection to take the geometric edge off his computer simulations in favor of a more massaged, organic quality. The "atom" of computer graphics is the pixel. A pixel is simply a point of light in computer space. Computer images are formed by pixel mosaics and the more pixels an image has, the higher its resolution and quality. A typical color-television picture might hold 300,000 pixels; a single frame of *TRON* can require up to four million.

There are several ways to design a computer system that can create the high-quality three-dimensional imagery required by *TRON*. At Triple-I in Los Angeles—Taylor's base of operations along with the Disney Studio—a computer-graphics habitat, powered by a souped-up Foonly computer, crafts extremely artful pictures with polygons.

Walt Disney Productions

A *TRON* object—for instance, the MCP—is defined down to the last curl and line segment on a sheet of graph paper including a minimum of two views—front and side—so that the shape of the object is represented. The curved surfaces are subdivided into small polygonal facets. After the points of the polygons have been graphically transferred into the computer, the object can be portrayed in its full-color, three-dimensional form.

The design is encoded into the computer on a digital tablet—sort of a drafting board that transmits all lines and squiggles drawn onto a television monitor. The operator encodes the picture by using a hand-held "puck" as a stylus for tracing the lines on the tablet. A tiny bell dings every time the operator formally enters a line into the computer's memory. Once the geometry of the object is established, different properties such as color, transparency and surface characteristics are assigned to it. Then the object is placed into an environment that includes the simulated light conditions, the point of view of the scene's observer, and all the other objects in the scene. The scene-simulation system is programmed to accurately mimic the effects of light and shadow, so that polygons will automatically darken as they go into shadows, or glitter in the simulated sunshine.

After the polygons are defined, says Taylor, there are "tweaker" programs for "bending, twisting and stretching" them until they nestle perfectly on their digital frames. "It's like the bottom of the space shuttle," says Craig Reynolds, a Triple-I image maker, "put together tile by tile."

Disney "choreographers" confer via computer link-up with MAGI in New York about explosion sequence.

Richard Taylor, cosupervisor of visual effects, crashes momentarily over a *TRON* light table.

Assembling high-detail images with the polygon approach takes a great deal of time and lots of polygons. Tracking all those polygons also demands a vast amount of computer memory for each object. It took five Triple-I animators six months to produce six minutes of full animation material for *TRON*.

The MAGI approach to computer imagery is radically different. Tucked away in a science park in Elmsford, New York, MAGI is best known for its computer-aided design software. "We represent graphics with solids," says Phillip Mittelman, MAGI's founder and president. "As far as we know, we're the only company that works that way."

Sculpting images on a screen

Basically, MAGI starts out with a set of computer-generated three-dimensional building blocks on the screen—spheres, cones, cylinders, and so forth—and mixes, blends and sculpts them until they perfectly model the desired image. For example, a chair built the MAGI way might consist of four long, thin cylinders as legs with the bottom slice of a sphere perched atop them as the seat and a slightly warped oblong serving as the back; a pair of skinny ellipsoids might be the armrests. By juggling with solids, says Mittelman, MAGI can quickly—within a few days—model or create complex and intricate structures.

MAGI's computer graphics program, called Synthavision, relies heavily upon a technique known as ray tracing. It was inspired by, of all things, studies on nuclear physics.

Back in 1966, Mittelman was a physicist researching aspects of reactor design. Monitoring the flow of radiation is crucial to efficient reactor performance and Mittelman's group developed a computer simulation program that "bounced" radiation off the walls of various simulated reactor interiors to trace its path. This resulted in a virtual three-dimensional view of the reactor. "Well," says Mittelman, a hearty-looking technocrat, "it didn't take much to realize that light rays are similar to radiation rays." By having the computer simulate rays of light and color, Mittelman was able to generate a different approach to three-dimensional computer graphics.

One seeming advantage of the MAGI method over the Triple-I approach is that it is easier to animate the objects because the computer has only to track a few moving solids instead of working with a complex network of polygons.

MAGI tells its creation how to move on the screen with a director's language—a fairly easy-to-understand but difficult-to-implement set of commands patterned on how a director coordinates all his people and props on the set. "It only takes a couple of days to under-

Taking a break from production, Jeff Bridges (right) and Steve Lisberger (center) hit a local arcade.

stand it," says Chris Wedge, a fair-haired young fellow trained as a stop-action animator at State University of New York at Purchase. "The real problem is figuring out how to make the motion look real." Wedge has to draw on his experience animating real solid objects to enable the computer to let its imaginary solids perform in a way that the eye will accept.

Wedge is trying to get a "Recognizer"—an ominous horseshoe-shaped robot that soars above the plains of the *TRON* world—to twist and move along a certain path. Using the director's language, Wedge maps a series of coordinates on the X, Y and Z axes along which he wants the Recognizer to travel. He also tells the Recognizer how quickly to pass through certain point-sets; when to accelerate and when to stop. For the sake of speed, Wedge can work with what are the equivalents of rough sketches of the Recognizer for, as he puts it, "real time-motion testing." He literally puts the Recognizer through its paces, stepping it frame by frame to see if the device is twisting and turning as it moves along the programmed path. Wedge has all the tools to assure that the motion seems real—but he determines what "real" looks like.

Perhaps unfairly, the production of *TRON* divided MAGI and Triple-I into different camps: the Imagists and the Dynamists. The distinction is somewhat representative of the computer-graphics field at large. Imagists are primarily concerned with picture quality and texture, making sure that every pixel is illuminated to the precise density. Dynamists, on the other hand, are obsessed with motion. Objects have to wriggle, shake, slide and soar in a way that will not make the eye suspicious. If that means picture quality is sacrificed a bit, well, that is a necessary price; there are always trade-offs.

"We felt that Triple-I was much more geared to beautiful imagery," says Disney's Bill Kroyer. "They put more emphasis on encoding objects than on

At his studio, Bob Abel examines *TRON* and other clients' filmstrips mounted on vertical light box.

choreographing motion, while MAGI was much more concerned with motion. So Triple-I's stuff tends to be glossier in appearance; MAGI's tends to have more dynamic action."

Consequently, MAGI was assigned the hard-action animation sequences whereas the Triple-I scenes have simpler action, with emphasis on visual beauty. Kroyer, a blond Midwesterner, is a nine-year veteran of traditional character animation. Along with partner Jerry Rees, his chief concern with *TRON* was assuring a delicate balance between the competing desires for lush imagery and believable motion.

"Our screen credit," says Kroyer, "will read 'Computer-Image Choreographers.' " The dance metaphor is deliberate since Kroyer and Rees look at image and motion as virtually indistinguishable. "You have to look at animation not just as a drawing," explains Kroyer, "but as a symbol of movement—even if it's only a smear of color."

Motion always complicates things. It changes angles and perspectives; light has to fall in different ways across a moving surface; colors shift, yet there has to be a continuity of detail as the object moves from frame to frame. Freehand animation is consequently an extremely arduous task, and reconciling character and action is the crux of the challenge for animators. They often took shortcuts, as with Mickey Mouse. Look carefully at his ears as Mickey leaps from scene to scene. "The ears were always circles," said Walt Disney, the master, "so they could be drawn the same, no matter how he turned his head." And one reason why Mickey's begloved hand has only four fingers, said Disney, is that "it meant one less finger to animate." It might seem odd to say, but detail is the bane of traditional hand animation.

Computers, on the other hand, thrive on detail. They could be used to re-create Bambi and Thumper —but that is not what they represent. The goal of entertainment that is believable is still the same—but the computer changes the old rules and increases the new possibilities.

"Usually," says Jerry Rees, a 25-year-old animator who used to hang around the Disney lot as a child, "you have an idea and it's great—but you have to weed out things either because of cost or because it would take 40 years to draw. This changes the way I think about film—I think more freely now. We had a scene where the 'Light Cycles'—futuristic 'motorcycles' —were racing down the canyon and we wanted to convey a feeling of fear as they came to the edge," he continues. "We had a 'camera' view from behind the cycles and a camera view from the top. We combined them and swept up to the top view as the Light Cycles abruptly stopped at the edge. It would be almost impossible to do a scene like that with either traditional animation or live action."

One problem is the dreaded jaggies

Even so, hand animation remains an important medium. At one stage, says Rees, "I was trying to get something to rebound off the wall and I thought a mathematical equation would do it for me. It couldn't and I had to block out the sequence by myself."

Even worse is when the computer-graphics programs themselves go awry. "Yeah," says Richard Taylor, "the jaggies or aliasing, and dropouts—you name it, we have it."

The dreaded jaggies occur if polygons are not smoothed precisely into their allotted spaces or if the fit is only good in one dimension; as the object rotates, a jagged set of steps crops up along a curved edge of the image. It looks like the top of a soup can that has been through an electric can opener.

Dropouts are just that: slivers of the object just drop from sight, leaving holes.

Since computer-graphics systems have so much information to track and because people feeding the system information do not always structure it properly, computers develop flaws. Images unravel or vanish as they are called upon to perform. All media have their limitations—in the case of computer images, the infinity of options creates an equally infinite opportunity for error.

Nowhere does this become more evident than in the daily *TRON* rushes at the animation building, located at the corner of Mickey Avenue and Dopey Drive at

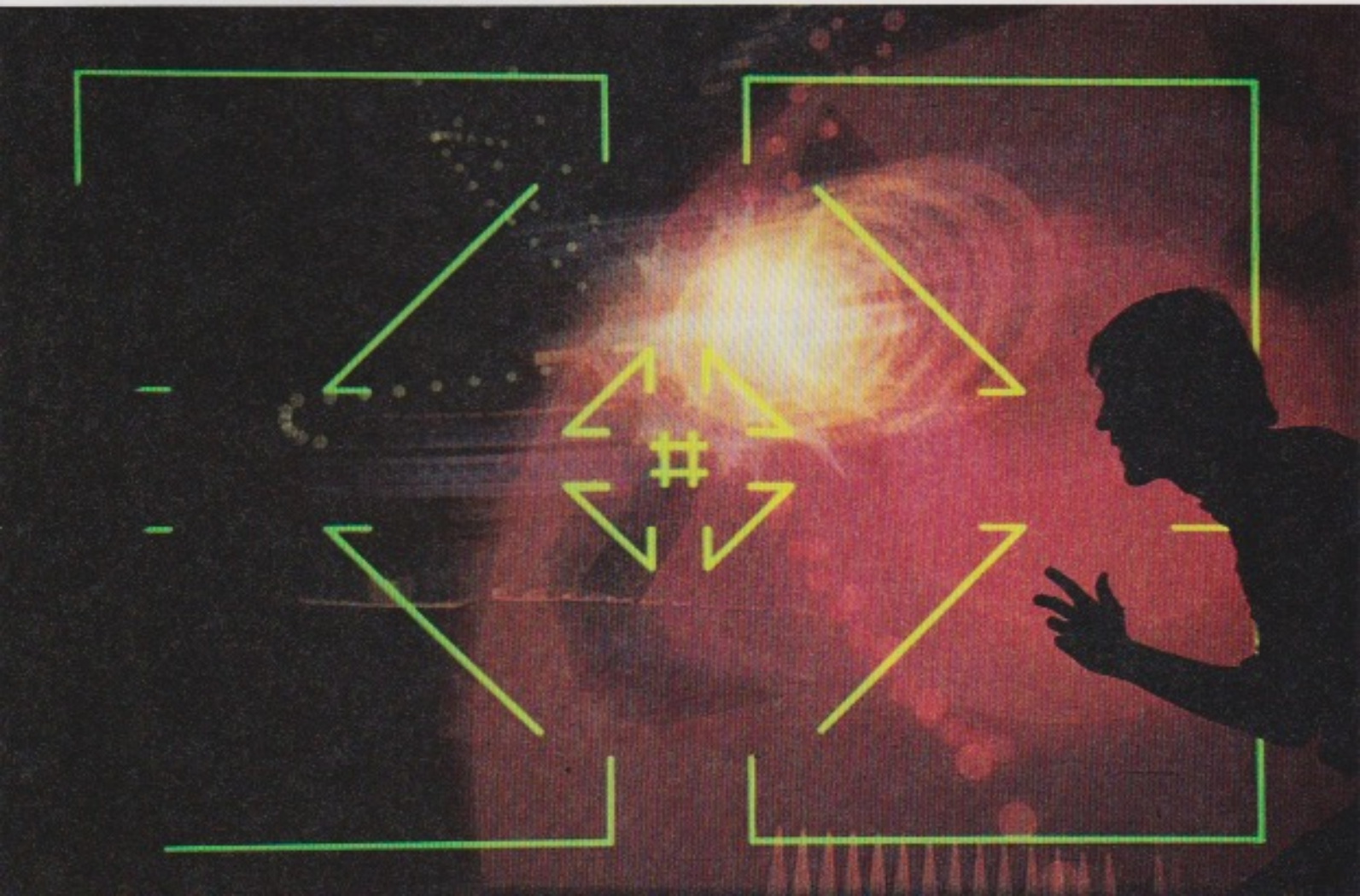
Disney Studios. Animators and color people file into a screening room that looks like a junior high school auditorium to view scenes of *TRON* animation that will eventually be edited into the final film. Richard Taylor chairs the proceedings as the lights darken and the projectionist starts looping the segments on the screen. The first loop features one of the live-action characters kneeling by a crystal pool for a drink. His uniform has a soft luminous glow streaked by bright bands of color. As he lies flat on his stomach to drink deeper, his stomach completely disappears. Someone starts to laugh. The scene is played over and over again. Taylor identifies the problem and calls out "RDIP!" That means ReDoIfPossible.

The next loop has a live-action character swirling in the incredibly high-tech environment of a *TRON* tank that is chasing after the heroes. Taylor yells out, "A hero!" That shot is correct.

A few more loops go by and then one comes on screen that elicits more snickering from the audience. A few of the live-action characters are descending a set of hard geometric steps. Unfortunately, they sometimes seem to be stepping on thin air as they miss the step entirely, or sink to the thigh in the block.

Taylor explains that integrating the live action and the computer graphics is a real headache. The actors have to perform against a backdrop of black velvet with really no idea whatsoever of what their computer-generated environment is going to look like on the screen. Sometimes the animation is not "matted," as it is called, to the live action as it should be. The result is a crazy-quilt mix of images that do not match.

Taylor expects that sometime in the near future a digital film printer will be developed that imprints computer images directly on the film while a computer coordinates live action and animation. When that happens, Taylor predicts, the marriage of computer to celluloid will change the nature of movies forever. But *TRON* is the first step. "It made the crack in the wall," he says. "It's the beginning of a technical renaissance in the film industry."

With the computer as lens and paintbrush all in one, it is appropriately ironic that the first film to successfully use computer graphics is about a computer.

In Disney animation building, tension runs high as *TRON* computer-generated footage is screened.